Polymers for an Energy Efficient Future

Lou Glasgow

DuPont

February 20, 2001

Agenda

- Major Trends
- The Biotechnology revolution
- Advanced materials
- Sustainable processes
- Summary

Agenda

- Major Trends
- The Biotechnology revolution
- Advanced materials
- Sustainable processes
- Summary

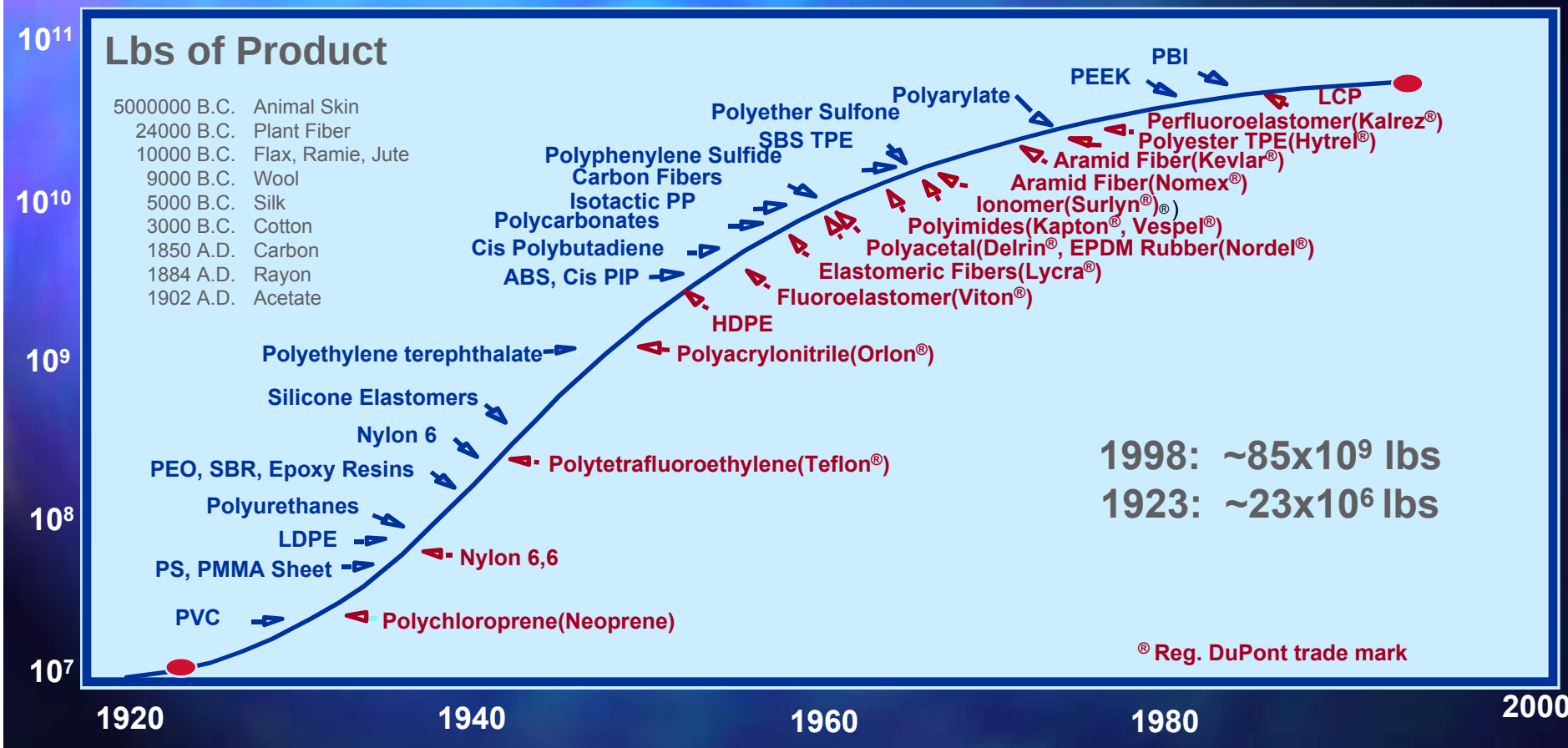
Major Trends

- Lighter, cheaper, greener
- Dematerialization
- Sustainability
  - Environmental footprint
  - Recyclability
  - Bioprocessing
  - Renewable feedstocks

Major Trends

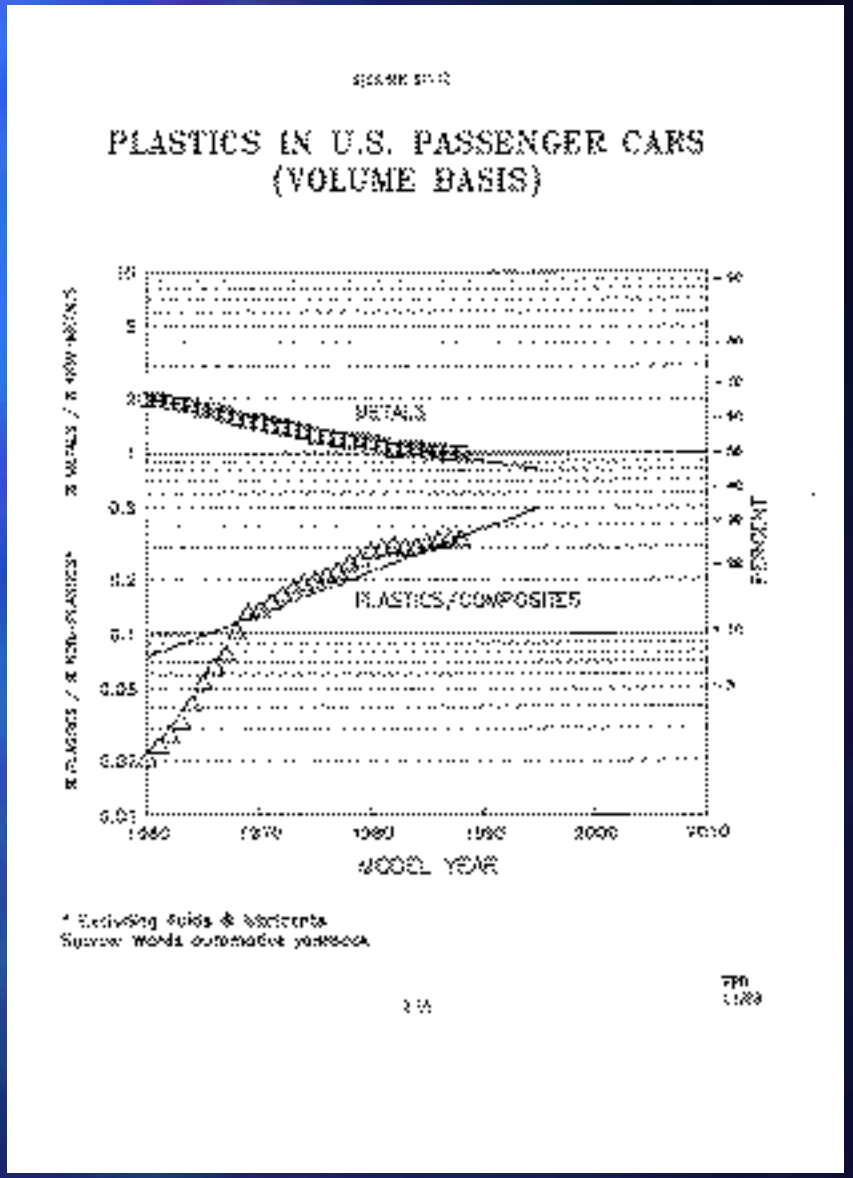
- Lighter, cheaper, greener
- Dematerialization
- Sustainability
  - Environmental footprint
  - Recyclability
  - Bioprocessing
  - Renewable feedstocks

U.S. Production of Petroleum-Based Polymers



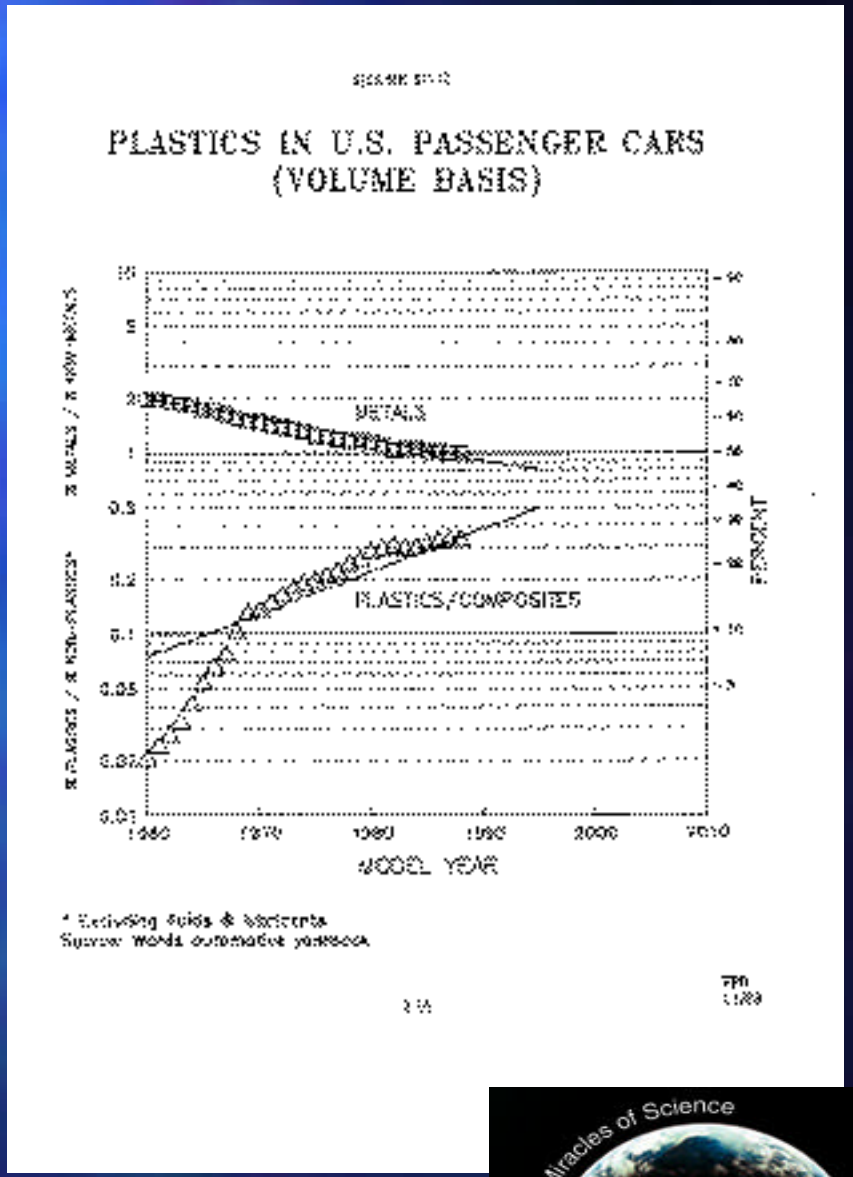
Major Trends

Plastics play a key role in energy efficiency through weight reduction of automobiles



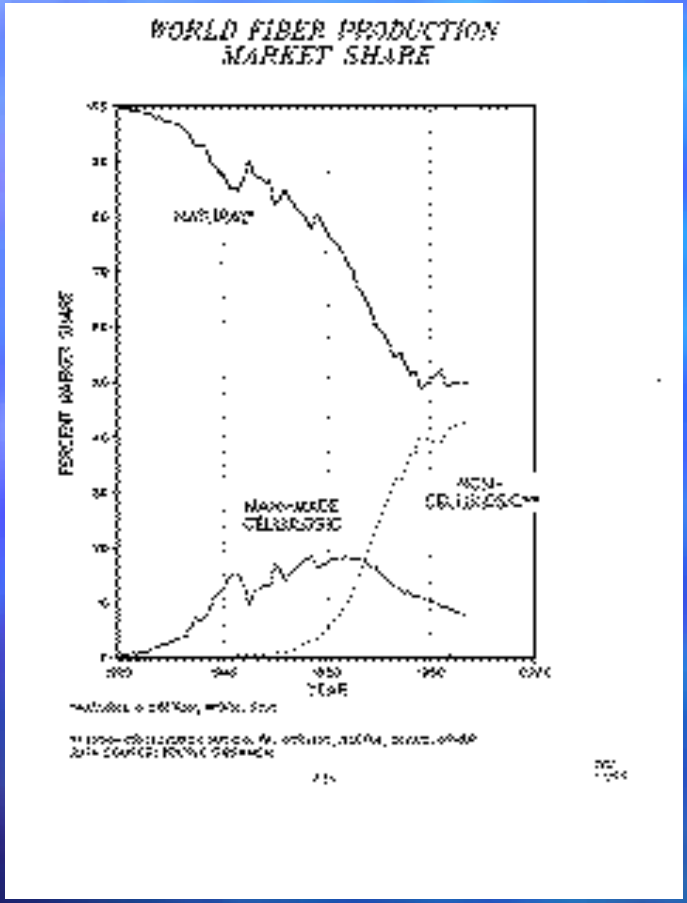
Major Trends

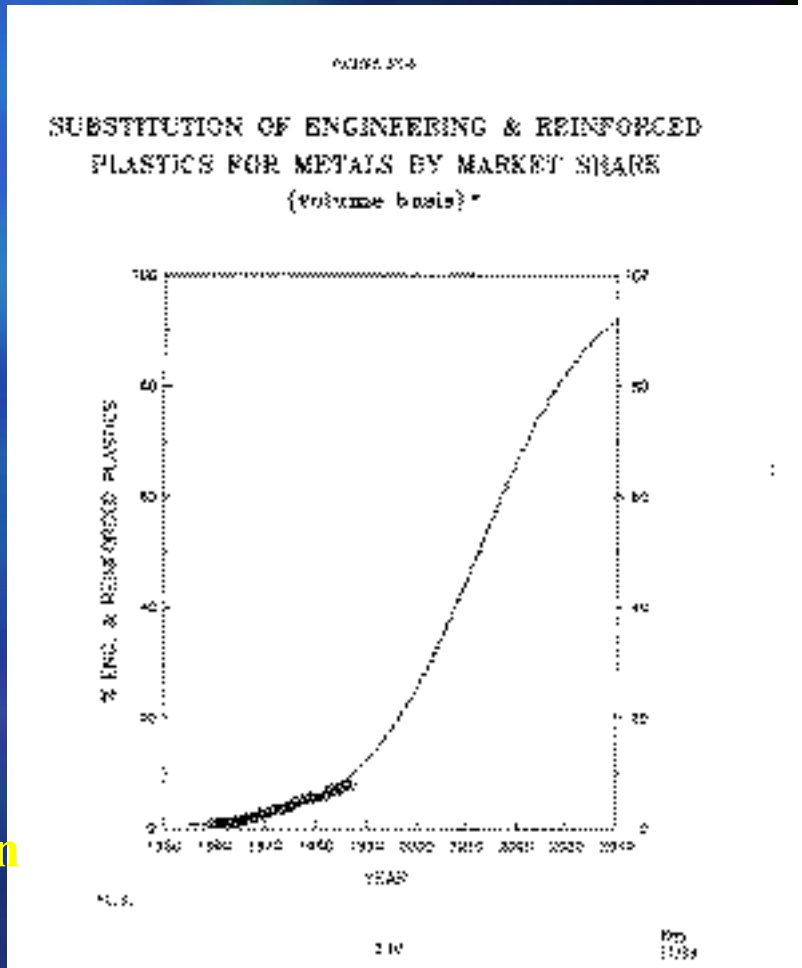
Plastics play a key role in energy efficiency through weight reduction of automobiles



Major Trends

Man-made fibers have largely penetrated natural fibers…..

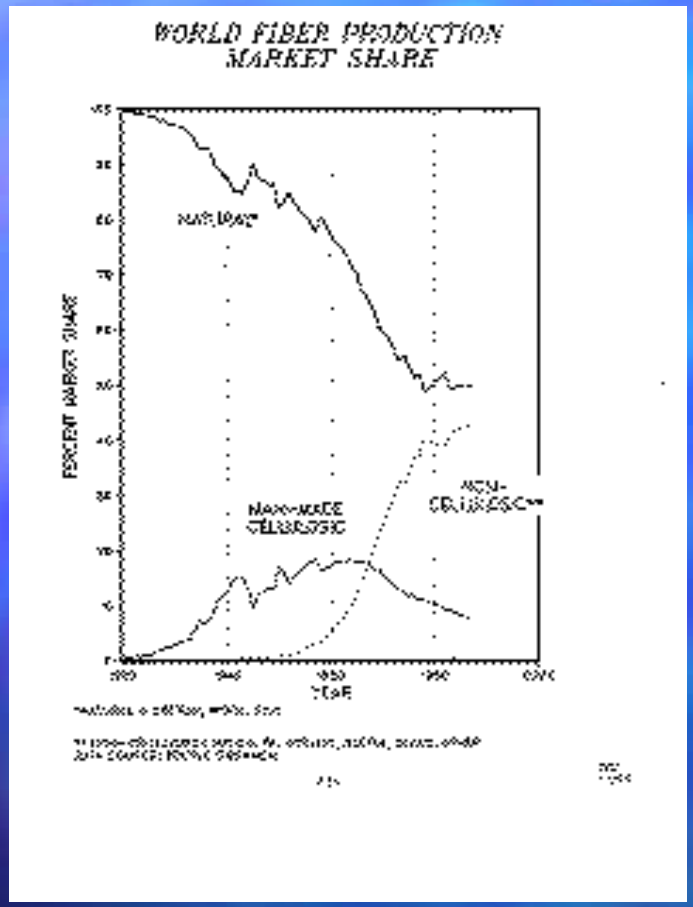


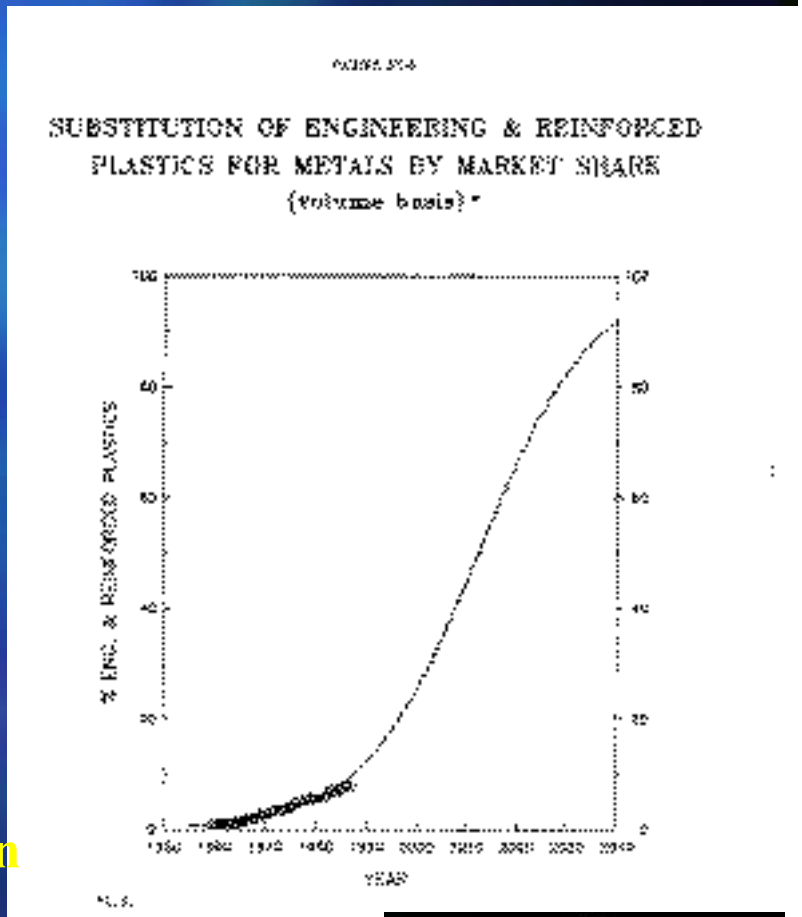


But we are still early in the game for penetration of metal and glass by polymers

Major Trends

Man-made fibers have largely penetrated natural fibers…..



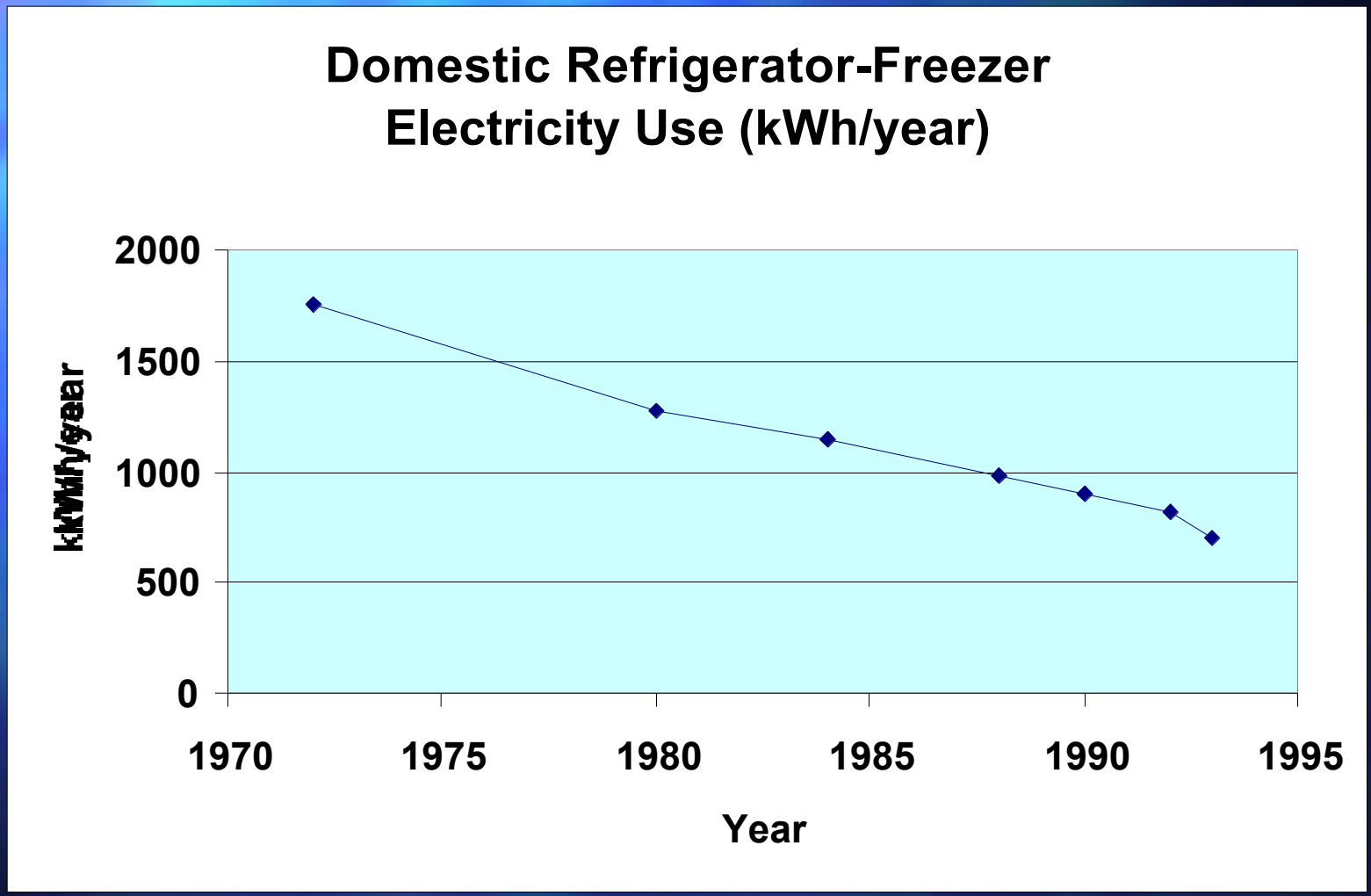


But we are still early in the game for penetration of metal and glass by polymers

Major Trends

The Miracles of Science
DUPONT®

Plastics and improved designs improve refrigeration and air conditioning energy effieciency



United States Data for 570 liter internal volume unit

New Science and Technology

- Genetic engineering
- Control of primary structure
- Control of nanostructure
- Biomimetics
- Self-organization, templating
- Combinatorial approaches

New Science and Technology

- Genetic engineering
- Control of primary structure
- Control of nanostructure
- Biomimetics
- Self-organization, templating
- Combinatorial approaches

Energy Efficiency Opportunities

A DuPont Perspective

- Improved production processes
  - bioprocessing/renewable feedstocks
  - plants as plants
  - sustainable processes
- Weight reduction
  - transportation
  - packaging/insulation
- Alternative energy
  - batteries, fuel cells,
- Photonics, electronics, semiconductors

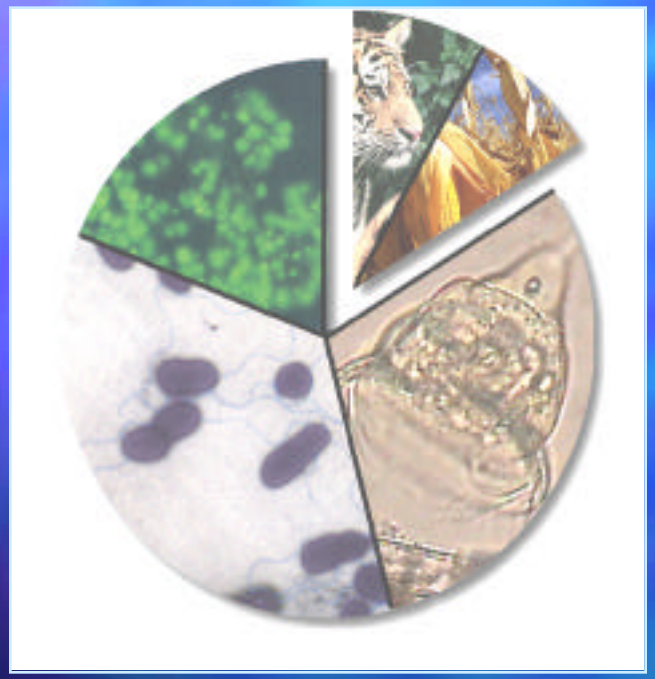
The Biotechnology Revolution

- Recombinant DNA technology
- Applications to chemicals and polymers
  - Propanediol and Polypropylene terepthalate
  - Plants as (chemical) plants
  - Biomimetic materials
    - Spider dragline silk
    - Abalone shell

Bio-Functionality: Link to Markets

Marketable Properties	Bio-Capability
• Increased strength and elasticity increased fracture toughness,	• Morphological Order
• Isotactic polymers, chiral chemicals, etc.	• Chemical Order
• Ability to distinguish subtle chemical size or shape differences	• Molecular Recognition/Selectivity
• Alter chem/physical behavior in response to environment	• Dynamic Surface Interactions
• Precisely Engineered Nanostructure	• Self-Assembly, Replication
• Precisely controlled minute motion	• Molecular Motion
• Eliminates/lessens rejection	• Bio-compatibility

Industrial Microbiology

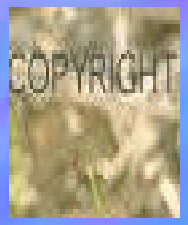


- Greatest biological diversity
- Broad range of feedstocks
- Chemically specific
- Commercial experience with enzymatic processes
- Minimal environmental footprint

Microbial Production of 1, 3- Propanediol

Plant Biotechnology

- Ultimate production platform
- Zero variable cost
- Unique functionality
- Economic product concentration key to commercial success



Enhancing Green Plant Production

Development of *Monomer*-Producing Plants

Development of green plant production of p-hydroxybenzoic acid, a key intermediate for DuPont's liquid-crystal polymer offering, Zenite®

1999

August - DuPont produces 5% *momoner* in Tobacco plants (20X literature's best)

1998

Literature reports Transgenic tobacco produces 0.25% *monomer*

1996

Literature reports plants that make 0.05% *monomer*

1993

Literature reports plants produce 0 - 0.0001%*monomer*

1988

Biotech Revolution

Green Plant Manufacturing Challenges

- Altering Agronomic Traits
- Growing on Non-Arable Land
- Manufacturing in Low Value Plants
- Flexibility in Processing Plants

Biomimetic Systems

- Biomimetic Catalysts
- Biomimetic Enhancement of Materials
- Biomimetic Chemical Processes